Forestcast Season 2: Backcross- Episode 5: Will Ash be the Blueprint for Tree Restoration?

Audio Transcript

Jon Yales

Welcome back to Backcross. The story of how resistance breeds restoration. This is part 5, the final part, and I'm Jon Yales.

Jennifer Koch

Yeah, so, as, you've probably heard, that when EAB [emerald ash borer] first was discovered, there were all sorts of reports that it kills healthy trees, it's killing all ashes, it's killing all species [of ash], there is no immunity, there's no resistance because it didn't co-evolve, there was mortality rates of 100%, and people were really predicting the end of ash trees, and didn't believe that resistance could be found in ash. We did find resistance, but it was a very subtle resistance, and it would have been very difficult to identify if we didn't have Kathleen Knight's monitoring work.

Kathleen Knight

So, at first with ash, we didn't know if there was any resistance out there on the landscape. And, it was in 2007 after I had been out monitoring my long term monitoring plots and counting dead tree after dead tree after dead tree, that on the way back to the car I found this beautiful, live ash tree that looked super healthy. And, the following year—2008—we really jumped in and tried to do some extensive surveys to look for more surviving ash trees, and we've found a number of surviving healthy ash trees, been able to sample those trees, and Jennifer's been working on a lot of the testing and assays on those, and found some really promising results.

Jonathan Yales

What was it like when you saw that tree for you as a scientist, like, where did it go from there?

Kathleen Knight

So, when we saw that first surviving tree, of course we took a bunch of pictures and selfies with it, but then the first thing I did was I went to Jennifer when I came back to the lab because I knew she had already started working on ash looking at Asian trees for resistance. And so, the first thing I did was to go to her and say, "Look, we found this amazing tree. It's really healthy. It's large. It's surrounded by all these dead trees. I think there might be resistance out there on the landscape."

Jonathan Yales

And, did anyone—you or Jennifer, or you know, anyone dealing with emerald ash borer—think there would be an opportunity for resistance, or was that just an unknown? Or, what was, kind of, the belief around resistance and ash back then?

Kathleen Knight

People believed that there was no resistance at the beginning. That was what we seemed to be seeing out on the landscape because it is so rare, and because in urban areas the ash trees that were planted had no resistance, so it was assumed that there was no resistance. So, that was why it was so exciting to find these first trees that really looked like they were doing something different.

Jonathan Yales

And, did you ever quantify out of—like, is this a one out of a million kind of tree? Is this a one out of a thousand or something like that?

Kathleen Knight

It's probably around one out of a thousand. It's tough to quantify because at some sites we've found one out of a few hundred, while at other sites we have found zero. But, looking at all the sites across Ohio that I've been monitoring, it appears to be less than one out of a thousand. That's still exciting, right, because that's a lot of trees. I mean, if it's one out of a thousand, but there were millions of trees out on the landscape prior to EAB, there could potentially be a lot of resistant trees out there. We just need to find them.

Jonathan Yales

And, you know, an imaginary person who is just walking through the forest sees one of these, what looks like a healthy, old, tall ash tree surrounded by dead ash trees, does that automatically mean it's a resistant tree that you're looking for or is there a more complex—is that not true, in a sense?

Kathleen Knight

Right, so we have been asking partners to look for surviving ash trees in areas that have been impacted by emerald ash borer. The context around that tree really matters. So, kind of midway through an emerald ash borer infestation, it's really typical to see a mix of healthy, dying and dead trees, but those healthy trees at that point are likely to just be dead within a few years. And, when we've tested those, they don't have resistance. So, you really need to wait until a few years after that 95% mortality point to start getting excited about a tree. And then, on the other end of things, if you wait too long afterwards, the trees that were too small to get infested originally when emerald ash borer came through, are now large trees, and so it's a little tough to parse out which of those larger trees you're seeing may have already been large when emerald ash borer came through and they were at a preferred size, and which of them were very small and have since grown to a larger size. So, the context of the tree you're seeing really matters, and that's why the long term monitoring data is so important to understanding what you're seeing. But, we are encouraging partners to, you know, kind of monitor long term and try to understand what's going on so they know the context around their trees, and to watch for trees and identify trees in areas that we know are at a point where it would be a good idea to look for these trees.

Jonathan Yales

And, why are they resistant, in a sense? Like, why are they standing there stronger than all the other trees around them?

Kathleen Knight

Right! So, that was the first question I had when I found the surviving trees. So, when we first found the surviving healthy tree, we wondered what could this tree possibly be doing different then all of these other trees that have died? And, one difference could be that the tree is just less preferred by the adults, it kind of smells different to them, it's emitting different volatile chemicals, so they don't prefer it, they go after the other trees first. Or, the tree could actually be doing something to kill the emerald ash borer larva as they try to tunnel into the tree and feed on the tree.

Jonathan Yales

So, to test these hypotheses, Kathleen took her thoughts - and her trees - to Jennifer.

Jennifer Koch

For myself, and the people in my lab, who are looking at things from a genetics perspective, we immediately thought that could be a sign of genetic variation, that might actually be a tree that has some level of resistance, and that is when we got involved. And, we've been working with Kathleen ever since to try to better define at what point it's best to try to select the surviving trees to increase the likelihood that they do end up being resistant. Right now—working from the trees that we have used, her monitoring plot data [is] a guideline to select them—about 50% of the trees that we have selected ended up having resistance based on our bioassay, meaning, they were able to kill more larvae than susceptible controls.

Jonathan Yales

And, when you said your team kind of gets involved and, you know, you're selecting for that resistance, like, what is that process? What is the general—

Jennifer Koch

Right. So, once we started seeing some of Kathleen's data, [next step] is going out to the field with her and looking at these trees, and the ones that looked the best to us, we collected scion—which is just collecting a dormant branch off of the tree—and grafted it onto rootstock, which is a way that allows us to make genetically identical copies of that tree that's growing in the forest, so that we can have a lot of copies of it to test with bioassays, and we did find differences that were measurable and reproducible. We found that there were some lingering ash trees that were able to kill more larvae. We found there were some lingering ash trees that produced larvae that had lower weights—they didn't weigh as much—which is an indication of, potentially, being less vigorous, which could potentially lead to them not being able to lay as many eggs or maybe not overwinter as efficiently—they may not survive over wintering. We also identified trees—lingering ash trees—that were less preferred by adults for feeding. So, when females hatch, they have to go through a period of maturation feeding before they can mate, and then mating occurs, most frequently, in the canopy, so the tree a female chooses to feed off of is going to be more likely for that tree to have the female lay her eggs on it. So, we found, you know, a couple of different ways that these trees are actually able to defend themselves against EAB to live longer than the rest. So, that's the first step, and that is usually the longest step in any breeding program, is developing that screening technique where you can reproducibly and quantitatively distinguish between each individual tree, the response it has to that insect or disease. And then, once we convinced ourselves that we were, you know—that this was real, and this was the reproducible screen, and an adequate screen—that's when we started the breeding work. And so, we started

breeding lingering ash trees with each other, lingering ash trees with known susceptible trees, and then susceptible trees with each other, so that we could have an array of controls. And so, over the past few years, we've been able to start screening the progeny of those families. So, at the beginning we produce very small families, but then as we replicate and get more and more copies of the tree big enough, we can produce more and more seed. We've screened at least 16 families at this point. And, this past summer, we screened our two biggest families—we were at about 115 trees in each family—and this was the first year we found some trees that were able to kill a 100% of the larvae that we put on them.

Jonathan Yales

Mhmm.

Jennifer Koch

So, that was really exciting. Over the three years, we have been getting trees that are killing 70%, 80%, 90% of the larvae that we put on them, but the next step in this is a bioassay, it's performed in controlled environments. These are potted seedlings, and because they're seedlings, it's a replicate of one. So, the next step is, the seedlings that perform the best, we have to make copies of those and then redo the experiment on, you know, a high, higher number of replicates to make sure that we can reproduce what we saw in that first trial. And then that one goes into the field so that we have—we're doing field trials as well.

Jonathan Yales

Mhmm.

Jennifer Koch

And, once we then confirm that when we put them out in the field, their performance has also improved over the parent trees, then I think we're closer to the actual improvement component where we're like, 'Okay, this whole process works.' So now, our hope is then that the best seedlings from those families will produce seed that is ready for that restoration component.

Jonathan Yales

How far are you away from moving to that next level, or feeling confident in being able to get close to restoration?

Jennifer Koch

I will feel much more comfortable after we've been able to replicate our best performing progeny in our bioassays, like once we have some [indescernable] field data but we're going to finalize that planting in the next year or two, and it could take like another seven years for them to start producing seed. So, somewhere between, say, five and 10 years.

Jonathan Yales

So, Jennifer had developed a successful breeding process, and had a idea of how long things would take to do things right, but she alone couldn't do it all. She needed to think bigger, she needed collaborators.

Jennifer Koch

Well, actually, when you were in Delaware [Ohio], that's what I was in, it was a Canadian-U.S summit meeting, and the whole goal of that meeting was to work together to try to accelerate our efforts to breed ash, so that we could then use it to build all the necessary infrastructure and, sort of, come up with a plan that would be followed using all of this new infrastructure, so that people knew, with the next invasive that comes along, this is the roadmap that you follow.

Jonathan Yales

So, she had a roadmap, but unfortunately, she still lacked a car.

Jennifer Koch

So, we have the research pieces in place, we know how to do the research that's required to implement a breeding program, but what we're lacking is that pipeline. So, when I described that process of breeding and how, you know, maybe in seven to 10 years, we'll have seed that's appropriate to start restoration with ash, that seed is probably only going to be appropriate to plant in, maybe, Indiana, Ohio and the lower part of Michigan, that's where it's going to be most adapted to. So, to restore a species across its entire range—and the range of green ash is about three quarters of the entire United States—means that the work that we've done has to be replicated in different regions to cover the entire range. And so, that is sort of the future, is building that network so that we have the capacity to do that, and the thought with the ash at this summit was that ash could serve as the model across Canada and the U.S. of how do we build these networks and mobilize them, and once we've done that it will be really easy for us to then plug in the next species because we'll already have these networks intact.

Jonathan Yales

We actually have a term for Jennifer's networked approach to solving large scale problems here in the Forest Service. It's called: 'Shared Stewardship.' But, Jennifer just calls it: 'Public-Private Partnerships.'

Jennifer Koch

So, in the spirit of shared stewardship, we have developed a couple of partnerships to help build this capacity and this pipeline. And, there's two of them right now, and they're very closely related, actually. One is called 'Roots of Rock,' and it is with American Forests and Fender Guitar and then all three branches of the Forest Service. Some of the goals of that project are to raise awareness with, sort of, just the general public, by doing some demo plantings in high profile areas. One is to work with American Forests urban restoration projects, like The Greening of Detroit, to get some of our potential ash and elm cultivars out in plantings.

And then, we have another project now, it's a Great Lakes Restoration Initiative-funded project.

So, the Forest Service, again across the three branches, decided that what they wanted to do with part of that funding this year is to form a forest health collaborative. Basically, I made a list of all of the stuff that I do that really isn't research [laughs]. So, that includes: reaching out and making partnerships with people like the states who help us go survey lands and identify resistant trees and collect scion and ship it to us so that we can propagate it; and finding partners that will allow us to plant test plantings, different progeny tests, or clone tests; finding partners that will do restoration plantings with some of the better material that we have that we want to test. So, the idea with the forest health collaborative is for them to bridge the gap between the research and operational, and interact with all of these little

interested groups, so that we can somehow coordinate efforts and train them and get them to, you know, help in the process. There's an amazing amount of people who really want to be involved.

Jonathan Yales

Keep in mind though shared stewardship is only one answer to our species restoration problems. And it's one that's usually done after the fact-after a tree species has already been put in danger. Similar to how we learned in Season 1 that the number one way you can stop an insect invasion... is to stop it from ever starting, who says geneticists can't acy in the same way—taking action before the trees are ever in danger? Well, they can, and that's just what Jennifer is doing today with collaborators out West.

Jennifer Koch

There's a species of ash, it's called Oregon ash, and it grows in Oregon and California, [and] Washington, it's a pretty important ecological species there as well, and there's a lot of concern about it, and we know it's very closely related to green ash. We've tested a very small number of them, it seems to be just as susceptible as green ash is.

[Phone ringing]

Richard Sniezko

Hello, Richard Sniezko.

Jonathan Yales

Hi, Richard. This is Jon.

Richard Sniezko

Hey, Jon. How's it going?

Jonathan Yales

Richard Sniezko is the Center Geneticist at the Forest Service's Dorena Genetic Resource Center out in Oregon.

Richard Sniezko

May of last year, I went to a meeting in Corvallis [Oregon], and what I heard there is, from the ground up, many of the municipalities were worried about ash.

Jonathan Yales

Over the past few years, Richard and Jennifer have been collaborating to get a little ahead of what could become a big problem for Oregon ash.

Richard Sniezko

They had written a—well, it's not an action plan, but something like an action plan—'Hey, ash is coming here. EAB is coming here. We're worried about it. Some cities like Corvallis were no longer planting ash, it's all toast, it's going to be toast, you know, five, 10, 15 years, whatever it is. We don't know what we're going to plant. We might plant exotic species.' And so, I'm sitting there as a tree breeder geneticist

saying, ‘Hmm, okay. Right now, I don't have any money. I don't have any charter to do this, but can I do something?’ And so, I asked somebody with our Forest Health Protection group—and we have some other pathologists and entomologists there—and I asked somebody in a Washington office if I could have a little funding to kickstart a program, and so, essentially I did. And then, I got some citizen scientists to collect some seeds, some people in other agencies and whatever, and they did all this kind of on their own type thing. And so, hey, here's a problem. Here's what we want to do. We want to look at it. I'm not guaranteeing people anything about resistance, but we'll have a look at this, and we'll link up with Jennifer back East because she has a protocol, we don't want to introduce EAB here to do it. So, it's a logical thing to look up, and then we’ll set it up so that when EAB does get here, we’ll have a planting and you can go through and see if, actually, there is any resistance. But also, we're realizing that, you know, if you don't get some success stories out there and show what can be done, then people won't know that there is an alternative to just letting the trees die and never getting it back out there.

Jennifer Koch

The reason I think it's important enough—and Richard has written other papers and other systems about that—is because it introduces the idea of doing breeding ahead of the insect or disease arriving, and I think that's really a key point. And so, if we can find those markers correlated with resistance in green ash, they might apply directly to Oregon ash, and that would really accelerate that process of resistance breeding. But, what we're starting with right now with Richard, is just a very simple screen. We're just going to screen a bunch of seedlings that he has collected from, you know, a pretty wide area of the range, and see if we can detect resistance. And, we've done that in blue ash and black ash, and we've been able to detect resistance.

Jonathan Yales

See, the future of resistance breeding and tree species restoration seems to lie right here, in these two combined strategies: Proactive breeding, and a shared stewardship approach.

With chestnut, you saw citizens...

Ella Preston

I don't like to lose a native tree of any kind. They have their place in all of our lives.

Jonathan Yales

And a non-profit...

Leila Pinchot

I just came back from their meetings, so I'm, like, still feeling that energy from that group.

Jonathan Yales

Both lead the way to finding a future for the species.

While, with elm, you saw how a farmer can become an integral part of the breeding.

Dale Lesser

So, I guess I really, I didn't get any income from it, but I met a lot of interesting people.

Jonathan Yales

And, now, with ash, you see the importance—and possibility—of proactively breeding, as well as how the combination of these two strategies could be the future for combating tree species restorations.

Jennifer Koch

You know, for a long time, I was trying to figure out how we could actually get the Dorena Genetic Resource Center of the East, and it's just not going to happen, I mean, at least not during my career, probably not in my lifetime. But, when I started seeing how much external interest there was from states, from local parks, metro parks, city parks, soil and conservation districts, other... there's a group in Columbus called Wild Things. It's just a group of people that are really interested in nature. And, they would be people that we could easily train and go out and report lingering ash. We're trying to sort of spread everything, and that's hugely time consuming, and it's a major undertaking, but once we build all of these networks, and can get everything up and running, it will be a model for the next species that's threatened like this, that we know, oh, this is what we did with ash, so this is what we need to do, and we already have all these groups in place that we know can do this work. So...

Jonathan Yales

Thanks for listening.

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Thanks for listening. See you soon.